Original Article
http://mjiri.iums.ac.ir
Medical Journal of the Islamic Republic of Iran (MJIRI)
Med J Islam Repub Iran. 2024 (6 Aug);38.90. https://doi.org/10.47176/mjiri.38.90

Schroth and Asymmetric Spinal Stabilization Exercises' Effectiveness on Back Pain and Trunk Muscle Endurance in Adolescents' Idiopathic Scoliosis: A Randomized Controlled Trial

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Received: 5 Mar 2024 Published: 6 Aug 2024

Abstract

Background: Millions of people worldwide suffer from back pain and muscle weakness due to adolescent idiopathic scoliosis (AIS). It has been found that Schroth exercises (SE) are the most effective treatment for AIS. However, it is still not clear how combining SE with asymmetric spinal stabilization exercises (ASSE) can impact back pain and trunk extensor muscle endurance (TE). This study aims to compare the effects of SE with and without ASSE on back pain and TE in AIS.

Methods: A randomized controlled trial was conducted with 40 boys aged 10 to 18 years who had AIS. They were divided into three groups: SE+ASSE (n = 15), SE only (n = 15), and a waitlist control (n = 10). The participants underwent exercise training for 50-70 minutes three times a week for up to 12 weeks. The study evaluated two variables, namely, back pain (measured with a Visual Analog Scale or VAS) and TE (measured with the Biering-Sorensen test), before and after the interventions. For statistical analysis, a post-hoc Bonferroni test following analysis of covariance (ANCOVA) was used at $\alpha = 0.05$.

Results: According to a study, patients who underwent a combination of SE and ASSE experienced a significant reduction in back pain (VAS score = 2.9±0.8 to 0.1±0.4) as compared to those who only underwent SE (VAS = 2.7±0.9 to 1.5±1.2) and the control group. No significant difference was found between the SE group and the control group in terms of back pain reduction. Furthermore, there was no significant difference in TE among the three groups. However, the combined exercises showed a numerical improvement (75.6±52.5 sec to 119.2±62.6 sec) compared to the other groups ($P = 0.311$).

Conclusion: The combination of SE and ASSE is more effective in reducing back pain in AIS than SE alone or control. Although there was no significant difference between the three groups in terms of improving the TE, the SE and ASSE groups showed better results numerically.

Keywords: Back Pain, Exercise Therapy, Muscle Endurance, Scoliosis

Conflicts of Interest: None declared
Funding: None

Cite this article as: Khaledi A, Minoonejad H, Daneshmandi H, Akoochakian M, Gheitasi M. Schroth and Asymmetric Spinal Stabilization Exercises' Effectiveness on Back Pain and Trunk Muscle Endurance in Adolescents' Idiopathic Scoliosis: A Randomized Controlled Trial. *Med J Islam Repub Iran.* 2024 (6 Aug);38:90. https://doi.org/10.47176/mjiri.38.90

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Introduction

Adolescent Idiopathic Scoliosis (AIS) is a common condition that affects around 80% of people with scoliosis (1). It causes the spine to curve sideways and rotate with a Cobb angle of 10 degrees or more (2). AIS is typically diagnosed during puberty and affects otherwise healthy individuals, with a prevalence rate ranging from 0.47% to 5.2% (3). The risk of progression is associated with the initial curve magnitude and remaining growth (1). This deformity can lead to back pain (4), muscle imbalance, respiratory problems, segmental instability (1), and changes in the characteristics of the erector spine muscle, such as decreased trunk extensor muscle endurance (TE) (5).

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↑***What is "already known" in this topic:***
The combination of Schroth and asymmetric spinal stabilization exercises is effective in improving the Cobb angle of AIS, but there is no evidence of its effectiveness in improving back pain and endurance of trunk extensor muscles.

→***What this article adds:***
The combination of Schroth and asymmetric spinal stabilization exercises is more effective than Schroth exercises alone in improving the back pain and endurance of trunk extensor muscles.

Various treatment approaches are available for treating AIS, depending on the severity of the condition (6). For mild cases (10 to 25 degrees), exercises may be enough to alleviate the condition. For moderate cases (25 to 45 degrees), a combination of exercises and bracing may be required. Surgery may be necessary in severe cases (more than 45 degrees) to prevent or correct any deformities caused by AIS. Exercise is an essential part of the treatment plan for AIS patients, regardless of the severity of their condition. It can be used as the primary treatment for mild cases and as a supplement to other treatments in more severe cases (1).

The main objective of treating AIS is to minimize the risk of further progression and establish a structural balance based on the radiographic outcomes such as the Cobb angle and Riser stage. There is also an increasing focus on non-radiographic outcomes such as back pain and TE (7). Back pain is a common symptom in children and adolescents, caused by muscle imbalance, fatigue, and spasms in the curved areas of the spine. According to a recent review, around 39.9% (95% CI: 34.2 to 45.9%) of individuals experience back pain due to AIS at some point in their lives (8). Reduced TE is believed to contribute to back pain. Therefore, it is essential to consider the potential impact of scoliosis treatments on these muscles (5).

Schroth exercises (SE) are widely considered to be highly effective in treating scoliosis, especially when used in combination with other general exercise methods (9). However, there is limited evidence to support their ability to alleviate back pain and improve TE (5, 7). Additionally, the asymmetric spinal stabilization exercises (ASSE) method has been developed to target muscle imbalances and correct scoliosis (10). When used in conjunction with the SE method, ASSE has been shown to be more effective in treating AIS as measured by the Cobb angle (11). Furthermore, numerous systematic reviews and meta-analyses have shown that core-based exercises are effective in reducing pain in both the general population and patients with back pain (12-15). ASSE is a subset of core stability exercises and can thus be an excellent option to combine with SE, as it can help alleviate back pain and strengthen TE. This can significantly improve muscle imbalance and TE in AIS patients (10, 11). However, no randomized controlled trial (RCT) has been conducted to study the effect of combined SE and ASSE on back pain and TE in AIS patients.

This study aimed to assess the impact of combining SE and ASSE, as opposed to using only SE, on back pain and TE in individuals with AIS. The secondary objective is to compare the effectiveness of SE with no intervention in the same group of patients. The hypothesis is that combining SE and ASSE will be more effective in reducing back pain and improving TE than using only SE or receiving no intervention at all.

Methods

Study design

A randomized controlled trial (RCT) was conducted at the Red Crescent General Rehabilitation Center in Tehran, Iran, from January 2022 to March 2023. Prior to the study, all patients and their parents were informed about the trial and gave their consent. The study was conducted in accordance with the 2018 Declaration of Helsinki (16) and was registered with the Iranian Registry of Clinical Trials (Code: IRCT20180727040609N1) on December 15, 2021.

Participants

The study involved boys with AIS and Cobb angles ranging from 10 to 30 degrees. These boys had Lenke curve types 1 and 5. A spine specialist diagnosed them with idiopathic scoliosis and back pain (11). The specialist then referred them to the corrective exercise department for exercise therapy services (17). Initially, the study determined the number of groups, which included two treatment groups and one control group. Each participant who joined the study was given an identification code placed in numbered envelopes containing a unique computer-generated sequence. The randomization process was supervised by the researcher (MA), who was responsible for data analysis. The randomization process used the "Research Randomizer" website software (https://www.randomizer.org) (18). The study's sample size was determined using G*Power 3.1 software. The alpha level was set at 0.05, the power at 80%, and the effect size at 0.88. With these specific parameters ($\alpha = 0.05$, power = 0.80, effect size = 0.88), the software calculated a sample size that is sufficient to detect a statistically significant effect, if one truly exists, with an 80% chance (19). According to these calculations, 30 participants were required, divided into three groups with 10 participants in each. To allow for potential dropouts, initially, 15 individuals were allocated to each group, totaling 45 participants. However, 5 participants didn't attend the post-test and were subsequently removed from the study. This left a total of 40 participants remaining in the study, resulting in the groups consisting of SE +ASSE (n = 15), SE alone (n = 15), and a waitlist control group (n = 10) (Figure 1).

Inclusion criteria

The study is seeking participants with mild to moderate scoliosis and experiencing back pain that affects the entire back for over three months, with a Visual Analog Scale (VAS) score of 2 or more. The participants should be between the ages of 10 and 18 and have a body mass index (BMI) of 30 or less. Individuals who have received any other treatments, such as wearing a brace, receiving massages, or undergoing physical therapy in the last three months, are not eligible for the study if they have AIS (27).

Exclusion criteria

The study excluded individuals who had underlying spinal pathology, such as a spondylolytic lesion, trauma-related diseases, non-idiopathic scoliosis, and neurological problems. Patients who were currently receiving treatment for AIS or back, had been prescribed braces or medicine, and were either unable to participate or unwilling to continue with the exercises were also excluded from the study (28).

[DOI: 10.47176/mjiri.38.90]

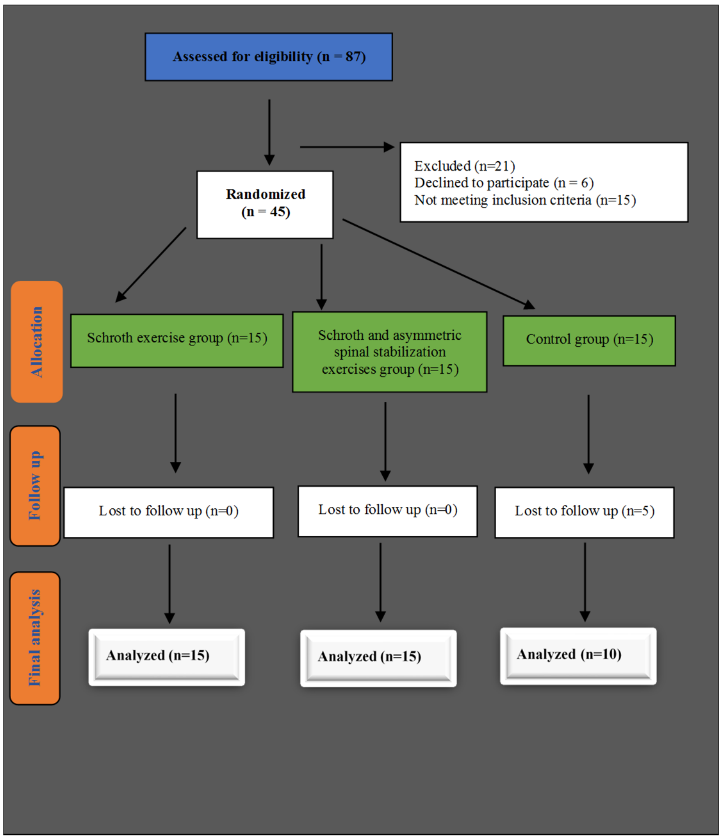


Figure 1. Flow diagram of the patients

Interventions

Both experimental groups in this study participated in SE, which included spinal elongation, de-rotation, de-flexion, and rotational breathing, as well as strengthening and stretching exercises. The combined exercise group also received additional ASSE, which involved a quadruped position (3 movements), prone position (4 movements), and a side bridging exercise to strengthen the back extensor muscles (specifically the gluteal, erector spinae, and paraspinal muscles). The participants performed these exercises for 50-70 minutes, three times per week, for a total of 12 weeks (20). Although the studies are very limited, some sources have reported the ASSE method's effectiveness in managing scoliosis (10, 11). The exercise program was developed based on the principle of FITT, which stands for frequency, intensity, time, and type (20). The program was conducted in a clinic under the supervision of specialists. The main exercise session lasted 40-55 minutes and was preceded by a warm-up (for 10 minutes) and followed by a cool-down (for 5 minutes). In contrast, the patients in the control group did not receive any therapeutic intervention during the research period. However, due to ethical considerations, they waited 12 weeks for the intervention. The control group was monitored during this period.

Asymmetric spinal stabilization exercises (ASSE)

The following exercises, called ASSE, can help improve spinal stability and balance: superman (Figure 2A), one-leg bird dog (Figure 2B), one-armed superman (Figure 2C), bird dog (Figure 2D), superman opposite arm and leg (Figure 2E), one-armed bird dog (Figure 2F), and one-leg superman (Figure 2G). The program includes three phases of progress (www.ncbi.nlm.nih.gov/pmc/articles/PMC6310602).

The initial phase is centered on enhancing muscle balance in the spinal areas by engaging in isometric contractions of core extensor muscles, such as the gluteal and erector spinae muscles. Each exercise in this phase consists of four sets, with each set lasting 10 to 15 seconds.

In the second and third phases, more intense exercises are performed to improve spinal stability and promote overall health through isotonic contractions (10). Each set in these phases consists of 6 to 12 repetitions.

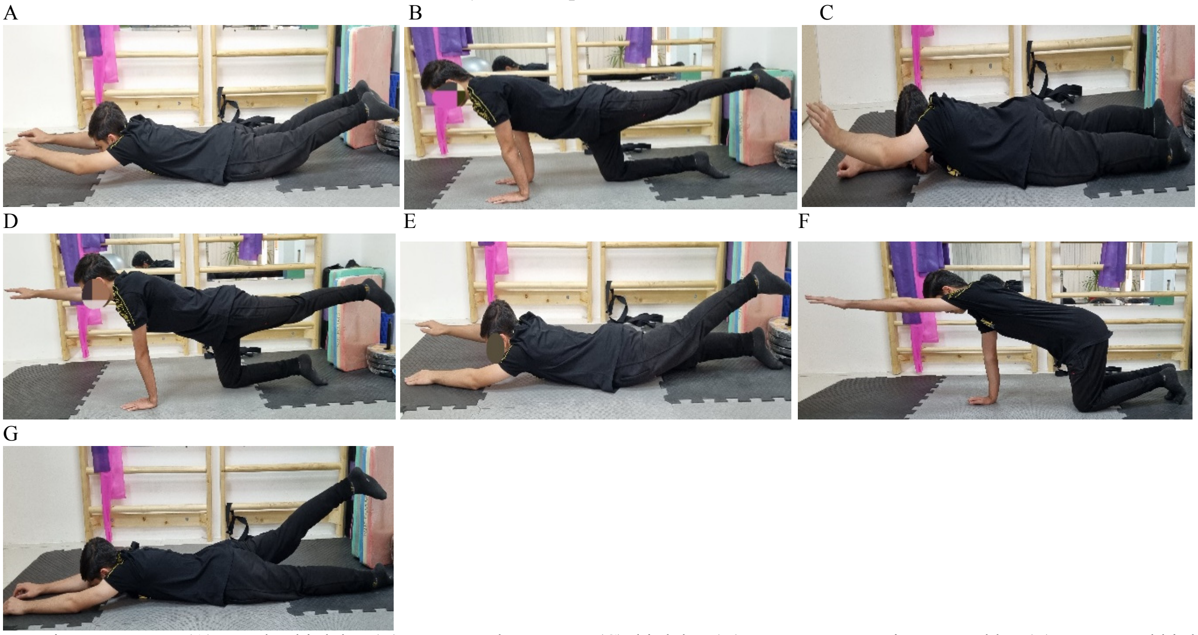
Schroth exercises (SE)

The SE includes hanging techniques (Figure 3A), correction of the lumbar region (Figure 3B), correction of the thoracic spine while sitting on a Swiss ball (Figure 3C), correction of thoracolumbar and thoracic regions (Figure 3D), muscle cylinder or correction of the thoracic region (Figure 3E), weak side traction (Figure 3F), and side bridge (Figure 3G) exercises to maintain vertebral alignment. It is suggested to perform 4-6 sets of 5-8 repetitions and progress from the beginning to the last weeks of treatment (21).

Outcome measures

Back pain was assessed using the visual analog scale (VAS), and TE (trunk extensor muscle endurance) was evaluated with the Biering-Sorensen test before and after the 12-week intervention period.

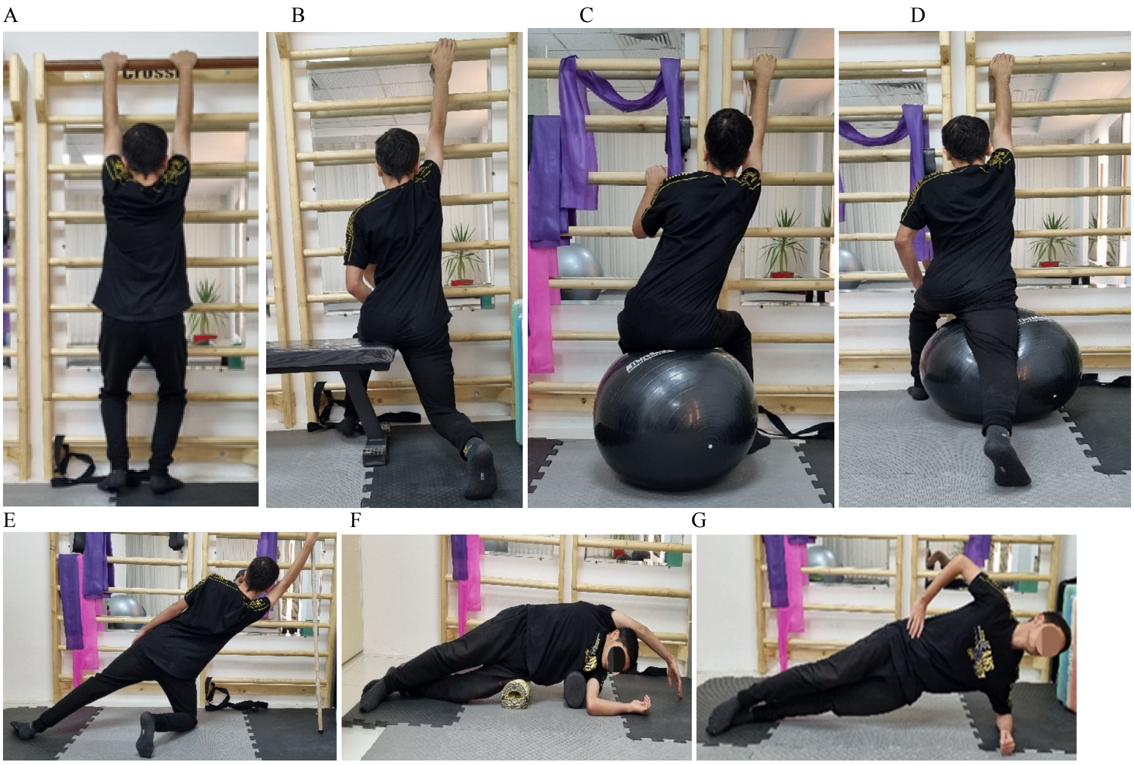
Asymmetric Spinal Stabilization Exercises



Exercises: superman (A), one-leg bird dog (B), one-armed superman (C), bird dog (D), superman opposite arm and leg (E), one-armed bird dog (F), and one-leg superman (G).

Figure 2. Asymmetric Spinal Stabilization Exercises (ASSE) include 4 sets of isometric contractions lasting 10 to 15 seconds and 4 sets of isotonic contractions consisting of 6 to 12 reps

Schroth Exercises



Exercises: hanging techniques (A), correction of the lumbar region (B), correction of the thoracic region sitting on a Swiss ball (C), correction of thoracolumbar and thoracic regions (D), muscle cylinder or correction of the thoracic region (E), weak side traction (F), side bridge (G).

Figure 3. Schroth Exercises (SE) include 4 to 6 sets lasting 30 to 90 seconds

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Measurement of pain intensity

The VAS test is a valid and reliable method for measuring the intensity of pain experienced by patients. During the test, patients are asked to indicate their pain level on a 10-centimeter straight line marked with ticks. The VAS measurement tool has high inter-rater reliability (ICC = 1.00) and test-retest reliability (ICC = 0.99) in clinical studies, with scores ranging from 0 (absence of pain) to 10 (the most intense pain) (22).

Measurement of trunk muscle endurance

The Biering-Sorensen test is a valid and reliable method for measuring the endurance of the back extensor muscles (23), with a test-retest reliability of ICC = 0.85 (95% CI: 0.76-0.90) and a standard error of measurement of 15.6 seconds (24). This test assesses the isometric endurance of the back muscles. To perform this test, the patient needs to lie face down on a table and hold their trunk in an extended position for as long as possible. The test concludes when they can no longer maintain proper posture or when 240 seconds have elapsed (23).

Statistical analyses

The data was analyzed using SPSS 22 software. The participants were grouped into three categories based on their age and body mass index. Analysis of covariance (ANCOVA) and Bonferroni tests were conducted, taking into account baseline values as covariates. The statistical analysis began with calculating the mean and standard deviation for the variables related to scoliosis. Then, normality (Shapiro-Wilk test), equality of variance (Levene's test), and covariance assumptions were checked, and the assumption of homogeneity of regression slopes was met. A statistical significance level of 0.05 was set.

Results

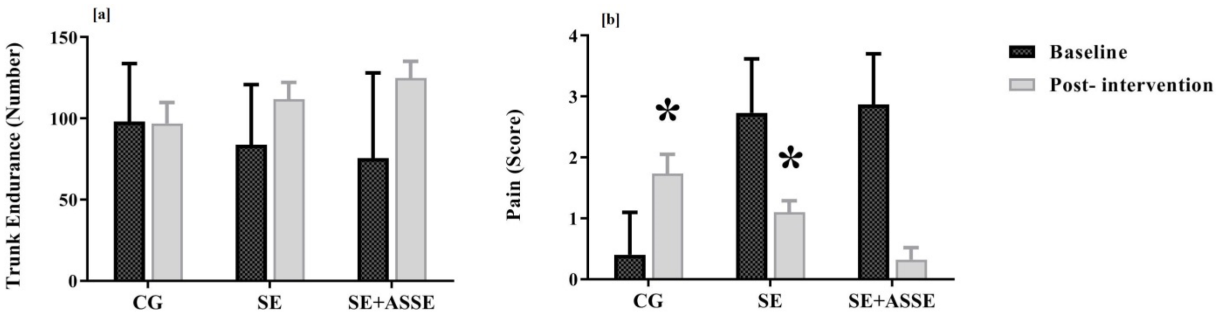
Forty patients with scoliosis, having a mean age of 16.1±1.3 years, were divided into three groups: Control (no intervention), SE alone, and SE+ASSE. Table 1 shows the baseline clinical and demographic characteristics of the patients. The age and body mass index or BMI of the patients in the three groups were not significantly different ($P > 0.05$).

There was a significant difference between the groups in terms of back pain ($P < 0.001$, $\eta2 = 0.5$). However, there were no significant differences between the groups for TE ($P = 0.259$, $\eta2 = 0.1$). Patients in the SE+ASSE group showed a greater improvement in back pain parameters than patients in the SE group (Mean Difference (MD) = -1.4, $P < 0.001$) and the control group (MD = -2.1, $P < 0.001$) (Figure 4A and Table 2).

Table 1. Baseline clinical and demographic characteristics of groups

Variable	CG (n = 10) Mean±SD	SE (n = 15) Mean±SD	SE+ASSE (n = 15) Mean±SD	*P*
Age (years)	15.4±1.5	16.3±1.4	16.3±0.9	0.170
BMI (kg/m2)	18.4±4.9	19.1±2.6	20.7±3.6	0.289

CG: Control group, SE: Schroth exercise, ASSE: Asymmetric spinal stabilization exercises, SD: Standard deviation, BMI: Body-mass index. *: Significant difference $P < 0.05$



* $P \leq 0.001$, a significant difference with the SE+ASSE group

Figure 4. Bonferroni post hoc test results for (a) trunk endurance and (b) pain

Table 2. Baseline, post-intervention, and change scores for trunk extensor muscle endurance and back pain

Variable	CG		SE		SE+ASSE	
	Baseline	Post-intervention	Baseline	Post- intervention	Baseline	Post- intervention
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
TE (Number)	98.1±35.8	105.8±35.2	83.8±37	111.5±37.5	75.6±52.5	119.2±62.6
Pain (Score)	0.4±0.7	0.5±0.8	2.7±0.9	1.5±1.2	2.9±0.8	0.1±0.4

CG: Control group, SE: Schroth exercise, ASSE: Asymmetric spinal stabilization exercises, SD: Standard deviation, TE: Trunk Extensor Muscle Endurance.

Although patients in the SE+ASSE group demonstrated a greater improvement in the TE parameter than patients in the SE and control groups, the difference was not statistically significant (MD = 27.8, P = 0.311). In addition, patients in the SE group showed a greater improvement in the TE parameter than patients in the control group, but this difference was also not statistically significant (MD = 14.9, P = 0.999) (Figure 4B and Table 2).

Discussion

This randomized controlled trial has found that a combination of "Schroth exercises" (SE) and "asymmetric spinal stabilization exercises" (ASSE) significantly reduces "back pain" in patients with "adolescent idiopathic scoliosis" (AIS) compared to those who only receive SE or no intervention at all. However, there was no significant difference in improving "the trunk extensor muscle endurance" (TE) between the three research groups. Nonetheless, the group that received the combined exercises (ASSE+SE) showed numerically better results. The research provides several new insights that contribute to the existing literature, which will be discussed below.

ASSE is a type of core stability exercise that has been found to be effective in reducing low back pain in the general population (12-14). The study tested the hypothesis that combining SE and ASSE can help alleviate back pain in AIS. Fortunately, the findings support this hypothesis. The findings showed that the combined exercises were more effective (VAS score decrease from 2.9±0.8 to 0.1±0.4) in reducing back pain than the two groups of the SE (VAS score decrease from 2.7±0.9 to 1.5±1.2) and control (no intervention). However, there was no significant difference observed in the comparison of the SE with no intervention.

ASSE targets the extensor muscles of the spine, specifically the erector spinae and gluteal muscles (10). These exercises are similar to the McKenzie method, which is also used to treat back pain and focuses on extensor mechanisms (25). ASSE can help reduce back pain, possibly because of this similarity. For instance, a study by Zapata et al. concluded that spinal stabilization exercises can reduce low back pain without significantly improving back muscle endurance in AIS (26). Similarly, a study by Gür et al. found that core stabilization exercises can be effective in reducing back pain in patients with AIS but did not show significant improvement in structural changes such as Cobb's angle and apical vertebral rotation (27). Another study by Yagci et al. found that core stabilization exercises were more effective at reducing back pain after four months than scoliosis-specific exercises, which are similar to the Schroth method (28). However, a systematic review provided limited evidence for the benefits of core stability exercises on back pain in scoliosis patients (29). It is worth noting that the researchers only considered articles that focused on adults with scoliosis, regardless of the degree of deformity (mild, moderate, or severe) and the type of stability exercises used (such as Pilates and yoga) in their research. This could be one of the reasons for the discrepancy in the findings of the present research.

While the Schroth method has limited evidence of effectiveness in treating back pain in scoliosis patients, two systematic reviews and meta-analyses have reported that there is insufficient evidence to support the effectiveness of core stability exercises in improving radiographic parameters such as Cobb's angle in cases of AIS (1, 30). However, ASSE is specifically designed to address muscle imbalances, particularly weaker muscles such as the paraspinal muscles located on the side of the concavity, and may be effective in improving the Cobb angle (10). When combined with the SE, which has been proven to be more effective than other exercise methods (11), ASSE can be the best option for reducing back pain in AIS patients while also decreasing the Cobb angle.

The second assumption of the current research was that ASSE combined with the Schroth method could improve the TE of AIS compared to SE alone or with no intervention. The idea behind this was that ASSE should naturally strengthen the back muscles in the extensor mechanisms (10, 25). Unfortunately, the findings of the research did not support this hypothesis. Although the experimental groups showed some numerical improvement in this variable, the control group also had improved records, and there was no significant difference in the improvement of TE between any of the studied groups.

It's important to note that the group who underwent both SE and ASSE showed better results than the group who underwent SE alone or no intervention at all. The improvement was seen in numerical but not statistical terms, with the Bairing-Sorensen score going from 75.6±52.5 sec to 119.2±62.6 sec in the combined exercises group, 83.8±37 sec to 111.5±37.5 sec in the SE group, and 98.1±35.8 sec to 105.8±35.2 sec in the control group. The training period was only 12 weeks, so it's possible that a significant difference could be observed in longer periods, such as 4 or 6 months. However, this finding is inconsistent with many other studies (5, 21, 31).

There are two possible explanations for the results, particularly the increase in the numerical score of the control group. Firstly, the learning process may be more effective during adolescence than in adulthood, so it's possible that the control group patients improved their neuromuscular adaptation after taking the Bairing-Sorensen test during the pre-test, which led to an increase in their score (32). Secondly, although the training lasted for about three months (12 weeks), the aging factor itself can be effective in improving strength and endurance (33). However, there was no significant difference observed between the groups.

Schreiber et al. conducted a study on TE, combining SE with the standard of care, and observed a 27.5-second difference compared to standard care alone. The study lasted for 6 months (21), which may be the most significant factor contributing to the difference in the findings of this research. In another study, Duangkeaw et al. observed an improvement in TE after 6 weeks of combining SE with Kinesio taping (31). One possible reason for the contradiction could be gender, as the subjects in these studies were all girls, while the present study only examined boys. Adolescent boys tend to have more muscle strength and endurance than girls (34), which could explain why the SE and ASSE

[DOI: 10.47176/mjiri.38.90]

used to improve the endurance of trunk extensor muscles may be considered too light and not follow the principle of overload (35).

There are still some unresolved issues about the effectiveness of therapeutic exercises, especially the combination of SE and ASSE on back pain and TE in AIS. These questions include whether gender (male or female), exercise duration (4 months or longer), and the severity of scoliosis (mild, moderate, or severe) affect the effectiveness of the exercises. Researchers are encouraged to investigate these factors, as well as the limitations mentioned below, in future studies.

The study had several limitations. Firstly, the treatment period was limited to 12 weeks. Secondly, there was a lack of access to girls despite scoliosis being more common in them than in boys. This could have impacted the results, as there may be differences between boys and girls. Additionally, there was a shortage of patients with more severe scoliosis. Finally, participants, assessors, and therapists were not blinded during the study. It should be noted that since these patients were only monitored for three days a week for about one hour, confounding factors such as the amount of daily activity, sleep and nutrition, and stress level were not controlled in the research, which can affect the results.

On the other hand, the present study had several strengths. Firstly, braces were not used to diagnose the effects of therapeutic exercises in the experimental groups accurately. Secondly, the study followed an RCT design, which means it included a control group and a follow-up period. Lastly, the study was the first to investigate the effectiveness of the combination of SE and ASSE on back pain and TE in AIS.

Conclusion

The research conducted has concluded that a combination of therapeutic exercises, including SE (Schroth exercises) and ASSE (asymmetric spinal stabilization exercises), is more effective in reducing back pain for AIS (adolescent idiopathic scoliosis) patients as compared to using SE alone or no intervention at all. However, no significant difference was observed in back pain between the SE alone and no intervention groups. Interestingly, the study found no statistically significant difference in TE (trunk extensor muscle endurance) between the three groups. Nonetheless, the combination of SE and ASSE demonstrated numerical superiority over SE alone and no intervention. Additional research studies are required for a minimum of four months or longer, with a specific focus on patients with AIS whose scoliosis severity exceeds 30 degrees, particularly focusing on girls. This will help us gain a more accurate understanding of the overall impact of SE and ASSE on back pain and TE for this group of patients. Nevertheless, based on the findings of the current research, it may be suggested that therapists employ combined exercises to manage and alleviate the back pain of AIS.

Authors' Contributions

Conceptualization and design: All authors; Methodology: Arash Khaledi, Mahdieh Akoochakian, and Mehdi Gheitasi; Data collection and analysis: All authors; Writing original draft: Arash Khaledi; Revisions and editing: Hooman Minoonejad; Resources: All authors; Supervision: Hassan Daneshmandi and Hooman Minoonejad.

Ethical Considerations

The study complied with the Declaration of Helsinki 2018 and was approved by the Ethics Committee of the Sport Sciences Research Institute in Tehran, Iran (Code: IR.SSRC.REC.1400.108).

Acknowledgment

The authors express their gratitude to all the adolescents who participated in this study and their parents.

Conflict of Interests

The authors declare that they have no competing interests.

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[DOI: 10.47176/mjiri.38.90]